Rogue River Temperature Analysis Above and Below Rockford Dam

Jay K. Wesley
and
Scott K. Hanshue

Michigan Department of Natural Resources

Fisheries Division

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Introduction:

The Rogue River is a major tributary of the Grand River and is designated as a Department of Natural Resources Natural River (MDNR 2002). It drains an area of approximately 234 square miles in Newaygo and Kent counties. The Rogue River is a medium-sized system that changes from a warm-transitional to cold-transitional stream as localized ground water inputs increase as the river flows down into the Grand River Valley. The river supports a popular stocked brown trout and rainbow trout fishery above the dam at Rockford (Figure 1). Downstream of the dam the river is known as a good steelhead fishery. Several of its tributaries, including Duke, Cedar, Stegman, Shaw, and Rum creeks have self-sustaining brook trout and brown trout populations (Hanshue and Harrington 2012).

Water temperature is a key habitat feature that affects both fishes and aquatic insects. Stream temperature affects rate of feeding, metabolism, and growth of stream organisms and is an important contributor to the observed differences in species assemblages between sites (Wehrly et al. 1999). The amount of groundwater entering a stream, presence of shade, warmwater discharges, air temperature, and presence of dams can all affect the temperature in streams.

Dams impound water causing the river to flow slower and absorb more solar heat. Some dams can raise the temperature enough to change or affect the fish community below the dam. These temperature effects can be mitigated through installation of bottom draws that pull up coldwater from the bottom of the impoundment, by reducing the impoundment size, or by removing the dam.

Rockford Dam is located approximately 3.5 miles upstream of the river's confluence with the Grand River and is owned by the City of Rockford. The dam was originally constructed in 1888 of wood and was used to power local mills. The structure was weakened by the 1904 flood and breached by a high water event in 1905. The existing structure and spillway were rebuilt in 1920 and later retrofitted to generate electricity. The dam provided hydroelectric power to the city until the 1960s. Recently, the dam was renovated and serves to maintain the impoundment and create a destination area for Downtown Rockford. The city beautified the dam by adding a catwalk and created a park like atmosphere around the dam. The dam has approximately 12 feet of head and maintains a 23-acre pond. The dam is considered to be a moderate hazard. The Rockford Dam is a barrier to upstream fish movement. The fishery in the Rogue River above the dam is mostly for brown trout and rainbow trout while steelhead, Chinook salmon, coho salmon, and brown trout make up the primary fishery below the dam.

The purpose of this report is to evaluate Rogue River temperature above and below Rockford Dam in support of Trout Unlimited's Rogue River Home Rivers Initiative Program to see if improvements can be made to the coldwater characteristics of the river.

Methods and Results:

Onset® Hobo® Temp Pro v2 temperature loggers were deployed on two occasions above and below Rockford Dam. The loggers were programmed to record water temperatures every hour. The first sampling from May 10, 2009 to May 16, 2010 was conducted by Michigan DNR, Fisheries Division with loggers placed upstream of the dam at 12 Mile

Road and downstream of the dam at 10 Mile Road (Figure 1). The second sampling from January 12, 2011 to December 08, 2011 was conducted by volunteers with trout unlimited. This sampling used a pair of temperature loggers at both the 12 Mile Road and 10 Mile Road sites.

Hourly temperature data were downloaded into a Microsoft Excel Spreadsheet for analysis. Data from the paired temperature recorders in 2011 were combined. Mean annual and mean July temperatures were calculated and compared for 2009 and 2011 using the Microsoft Excel Data Analysis Tools t-test: two-sample assuming equal variance with the null hypothesis that the temperatures were the same above and below the dam.

The annual mean Rogue River water temperature for 2009 was 50.3 °F at 12 Mile Road and 50.5 °F at 10 Mile Road with no significant difference above or below the dam (Table1, Figure 2). There was a significant difference between the July mean temperature above (62.9 °F) and below the dam (63.8 °F) (Figure 3). The annual mean temperature was higher overall in 2011 with no significant difference above (51.6 °F) and below (52.0 °F) the Dam (Table 1, Figure 4). There was also no significant difference in July mean temperature above (69.0 °F) and below (69.1 °F) the dam (Figure 5). The month of July in 2009 was the coldest on record for all of Southwest Lower Michigan with a mean air temperature of 65.4 °F, which was 4.8 °F below normal (Marino 2010). July of 2011 was very warm for Southwest Michigan with air temperatures 5.5 to 6.5 °F above normal (Jeruzal 2012).

Discussion:

The primary goals of Trout Unlimited and Michigan Department of Natural Resources are to protect and rehabilitate the coldwater resources of the Rogue River. This temperature study was conducted to see the effects of the Rockford Dam on river temperature. The Rogue River is managed for trout and salmon through the stocking of brown trout, steelhead, and coho salmon.

Although there was a significant increase in the mean July temperature below the dam in 2009, it was only by 0.9 °F. The mean July temperature below Rockford Dam was well in the range for good trout survival, growth and angler catch rates. Brown trout growth occurs when water temperatures are between 39 °F and 67 °F (Elliott 1993), and McMichael and Kaya (1991) observed that brown trout catch per angler hour decreased when water temperatures exceeded 66 °F. Similarly, brown trout in Jocassee Reservoir exhibited a preference for water $\leq$ 68 °F (Barwick et al. 2004) and data collected during the Michigan Rivers Inventory indicated that streams with mean July temperatures (MJTs) > 68 °F rarely supported sizeable trout populations (Andy Nuhfer, MDNR – Fisheries Division, personal communication). The mean July temperature in 2011 was warm, but appeared to be more correlated with air temperatures rather than any influence of the dam. The mean July temperature above and below the dam exceeded 68 °F making it marginal for trout.

The ultimate lethal temperature for brown trout is 85.8 °F (Elliott 1981). At this temperature, brown trout will perish in approximately 10 minutes. In 2011, the highest temperature recorded above the dam was 80 °F and 75.7 °F below the dam (Figure 5).

This was either an unusually warm day or the loggers became exposed to the air. The incipient lethal temperature for brown trout is 76.5 °F (Elliott 1981; Elliott 2000). This is the maximum temperature brown trout can tolerate for a 7 day period. The Rogue River stayed below this for both sites in 2009 and 2011.

The lower Rogue River also appears to be appropriately classified in Michigan's Water Withdrawal Assessment Tool. It is currently classified as a cold transitional stream in the lower reaches. Data from 2009, show the lower river close to a cold stream, which is characterized with mean July temperature <63.5 °F. In 2011, the Rogue River resembled more of a cool stream, which is characterized with a mean July temperature between 67.1°F and 69.8 °F.

Recommendations:

Rogue River stream temperature is strongly influenced by groundwater inputs to the river and climate. With the possible increase in air temperatures due to climate change, it will be important to maintain the hydrology of the river by protecting and restoring groundwater recharge and discharge areas. Below is a list of recommendations that will help the Rogue River remain a cold water trout stream.

- Remove or modify Rockford Dam to reduce the risk of evaporation and increased water temperature. Although the dam only had a one degree difference during July in 2009, this could potentially increase as the impoundment shallows and summer temperatures increase. With the dam recently being renovated, it will be difficult to achieve community support for removal. Modifications to the dam that would reduce the impoundment size could be beneficial.
- Enforce temperature discharge standards for cold trout streams with any future NPDES permits through Michigan Department of Environmental Quality.
- Better partnership and local government organization and communication to share information about groundwater and stream temperature BMPs and areas that need protection through local planning.
- Discourage building dams and lake level control structures that significantly degrade hydrologic regime and further warm the water.
- Discourage development in riparian zones through enforcement and possibly expansion of the Natural River Program.
- Encourage restoration and preservation of riparian zones to promote shading.
- Protect riparian greenbelts through adoption and enforcement of zoning standards.
- Improve and encourage standards to promote water infiltration and groundwater recharge.
- Maintain flow stability by reducing runoff in agricultural catchments through implementation of conservation programs (e.g., Conservation Reserve Program (CRP), Wetland Reserve Program (WRP)). Partner with state and federal Departments of Agriculture and county conservation districts to identify priority areas for restoration.
- Protect undeveloped landscapes through property tax incentives, transportation policies, integrated land use planning, conservation easements, and policies to encourage redevelopment of urban areas.
- Protect pervious open spaces by preserving agricultural landscapes through best management practices and agricultural zoning plans.

- Encourage protection of wetlands.
- Require policy and permits that consider accumulative impacts with water withdrawal.
- Educate public regarding threats of altered hydrologic regimes.
- Protect important and major ground water recharge and discharge areas.
- Support retention of the Rogue River USGS station.
- Partner with state and federal hydrologist to identify needs for additional stream flow gauges or miscellaneous flow measurements. Identify funding resources needed to improve collections of stream flow data.
- Protect and maintain flow stability by developing a hydrologic routing model for the entire river system that describes both ground and surface water routes in response to changes on the landscape.

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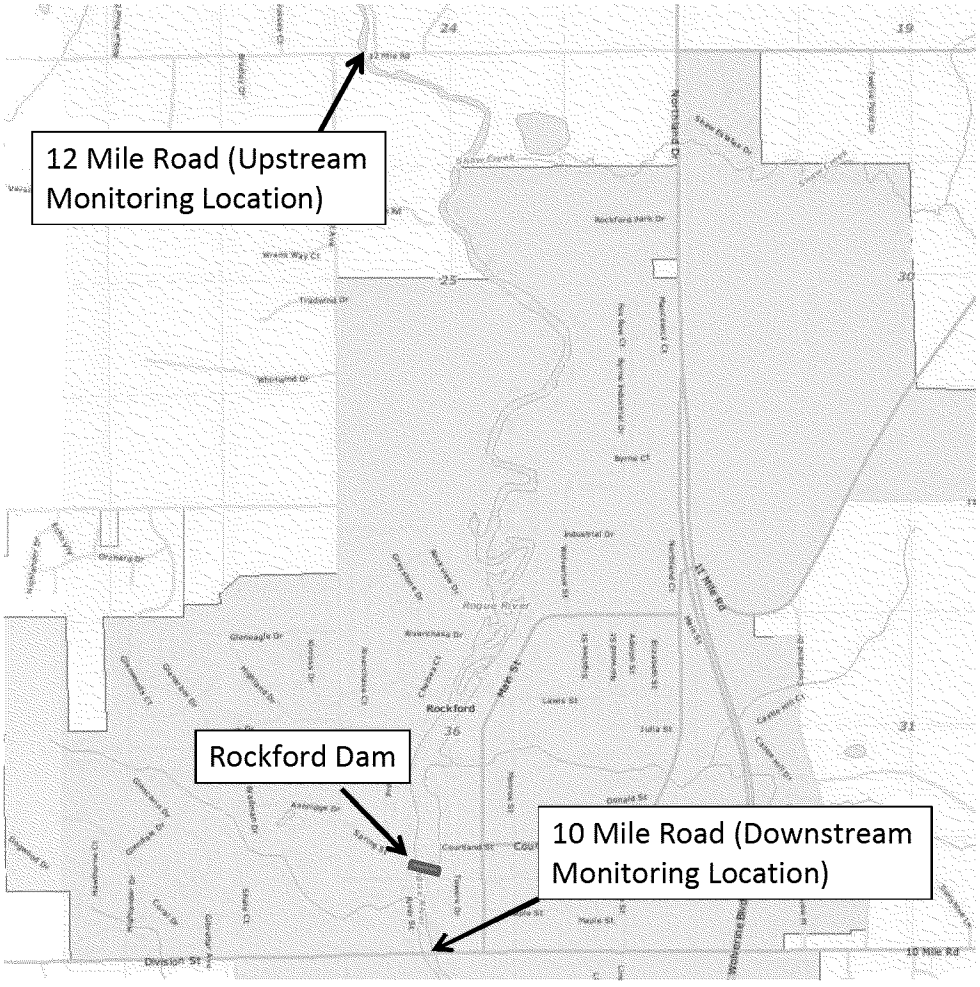

Figure 1. Location of temperature loggers in the Rogue River above and below Rockford Dam.

Table 1. Annual and July mean Rogue River temperature above and below Rockford Dam for 2009 and 2011.

Monitoring Period	Site	Annual Mean (°F)	Statistical Significance	July Mean (°F)	Statistical Significance
May 10, 2009 – May 16, 2010	12 Mile Road – Above Dam	50.3	Not Sig. P=0.17	62.9	Significant P<0.0005
	10 Mile Road – Below Dam	50.5		63.8	
January 12, 2011 – December 8, 2011	12 Mile Road – Above Dam	51.6	Not Sig. P=0.06	69.0	Not Sig. P=0.37
	10 Mile Road – Below Dam	52.0		69.1	

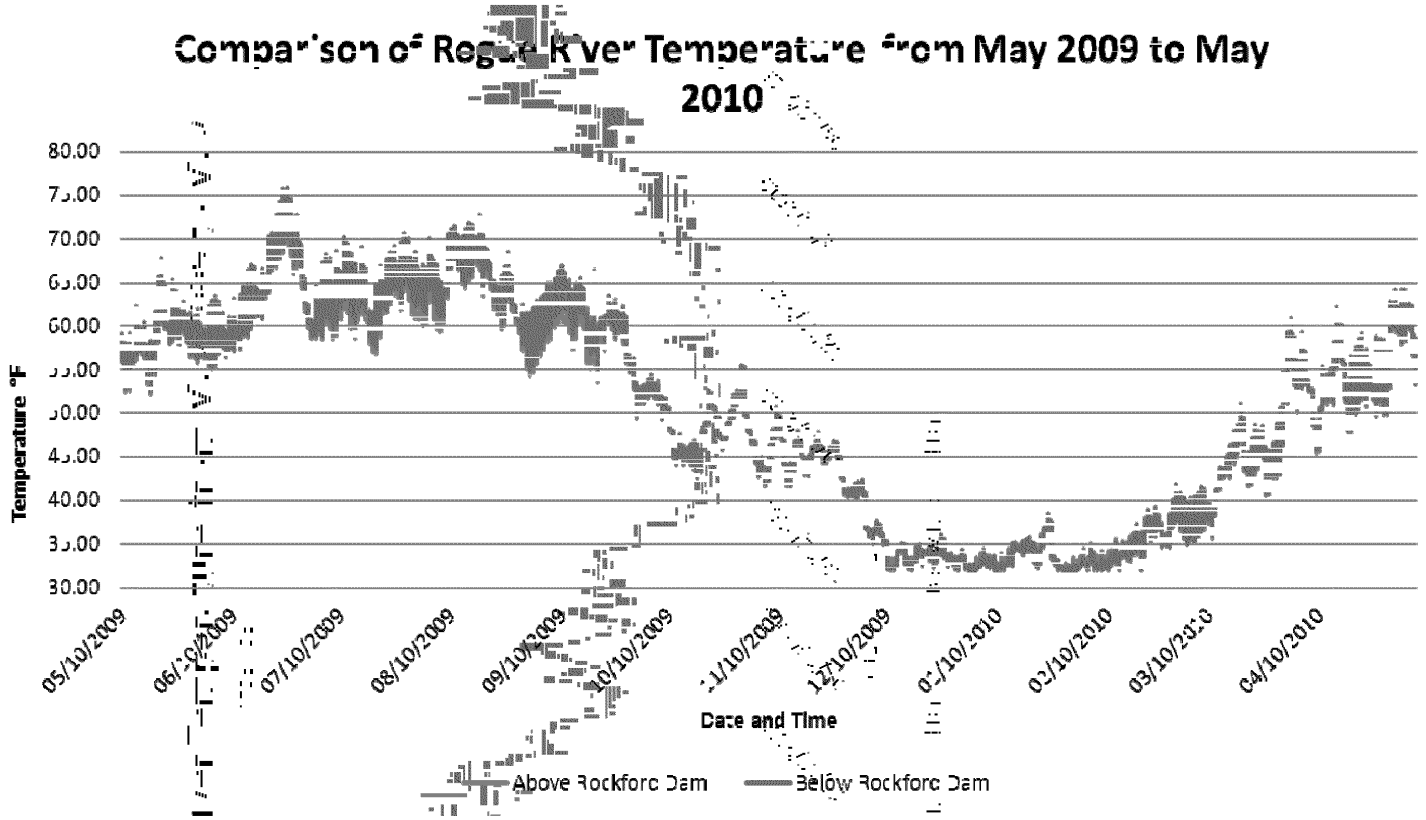

Figure 2. Rogue River daily temperature above and below Rockford Dam from May 10, 2009 to May16, 2010.

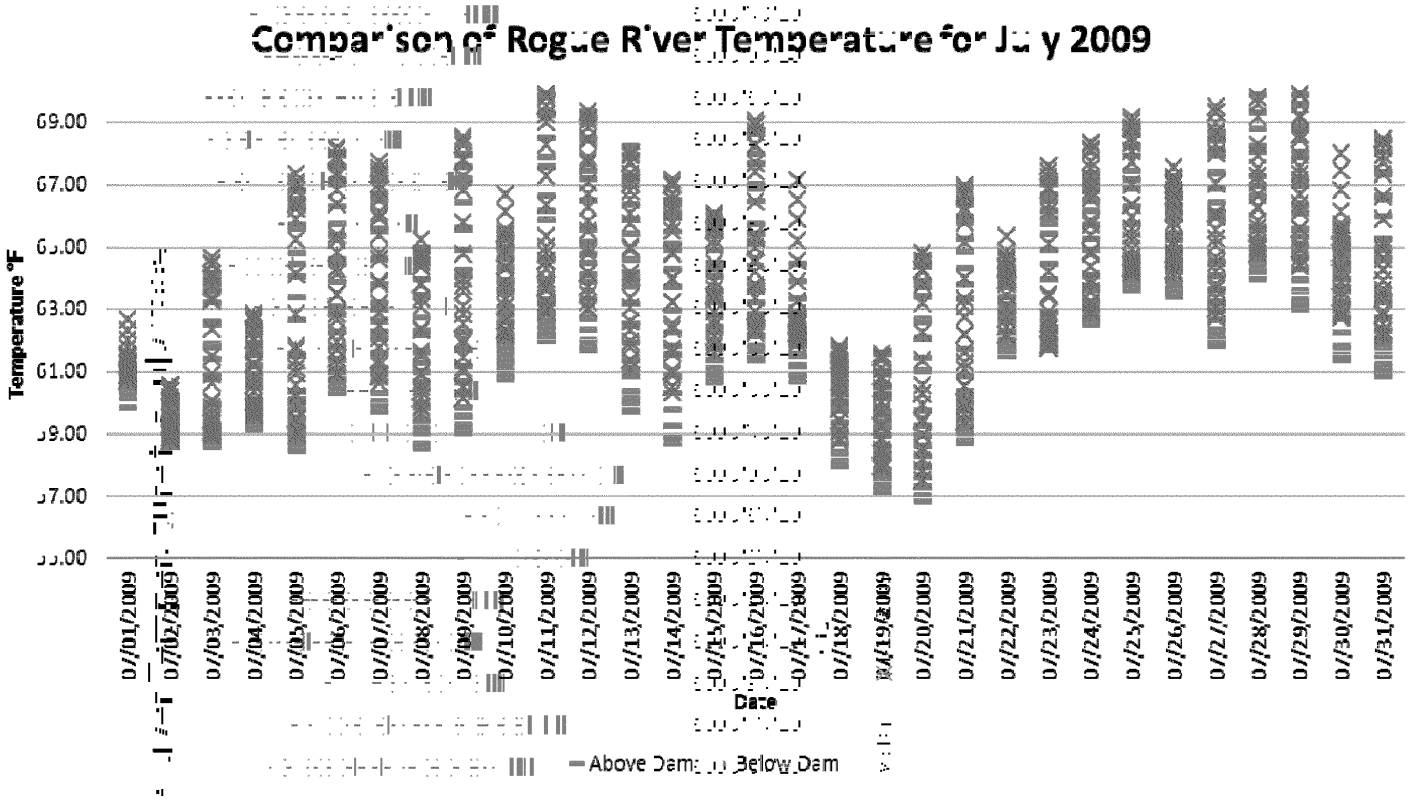

Figure 3. Rogue River July 2009 temperature above and below Rockford Dam.

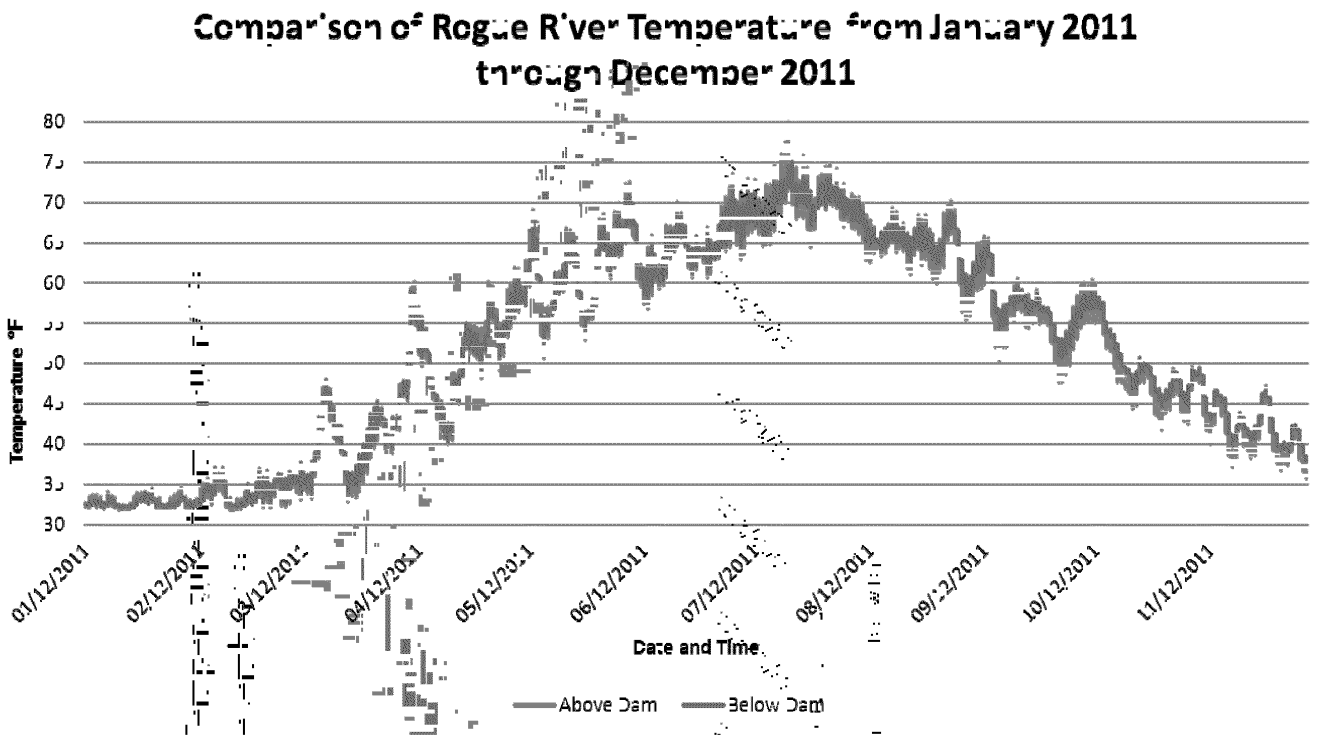

Figure 4. Rogue River daily temperature above and below Rockford Dam from January12, 2011 to December 8, 2011.

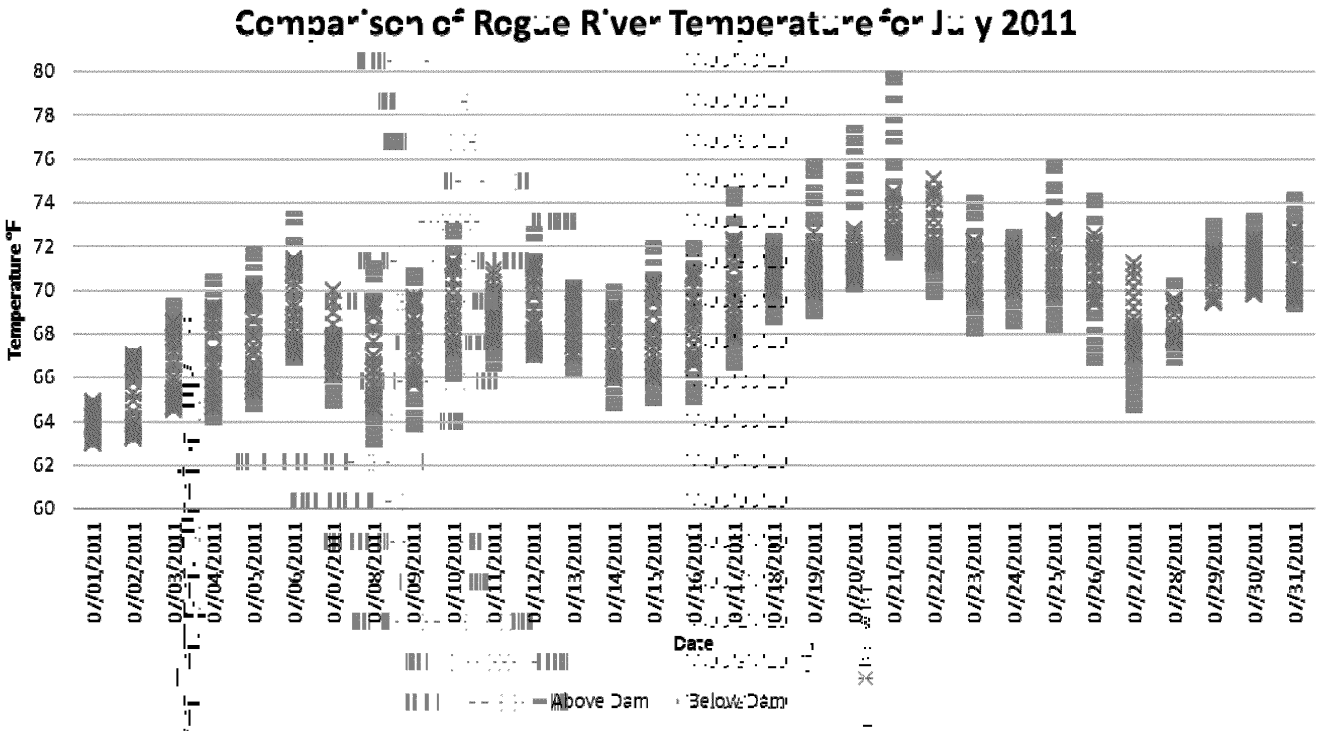

Figure 5. Rogue River July 2011 temperature above and below Rockford Dam.